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CSERIAC GATEWAY

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CSERIAC is a United States Department of Defense Information Analysis Center administered by the Defense Technical Information Center, Ft. Belvoir, VA, technically managed by the Armstrong Laboratory Human Engineering Division, Wright-Patterson Air Force Base, OH, and operated by the University of Dayton Research Institute, Dayton, OH.

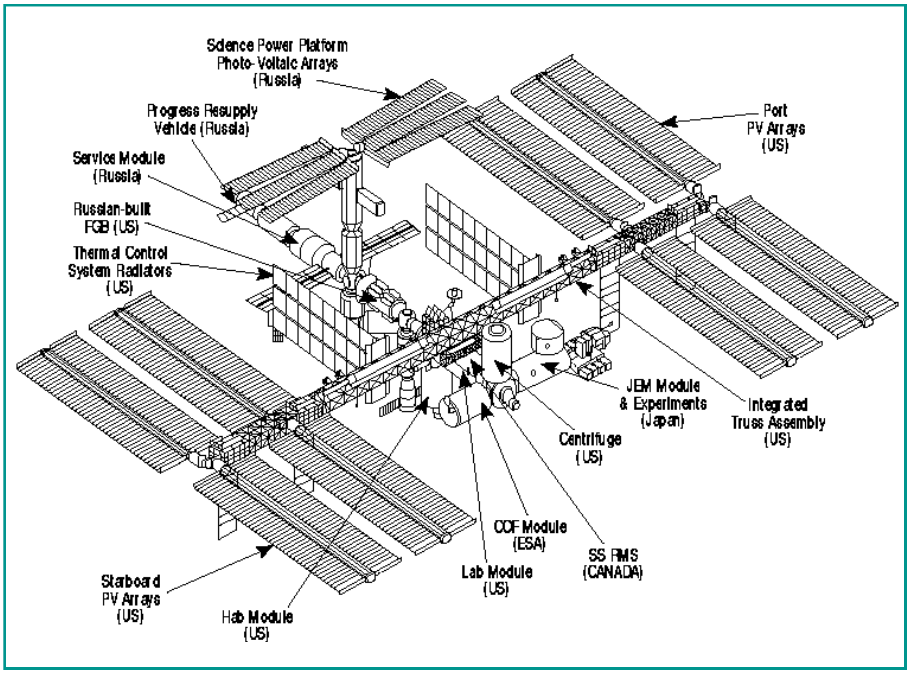

Figure 1. Prototype of the International Space Station. Illustration by Ronald T. Acklin, University of Dayton. Adapted from NASA.

Concerns for a Multicultural Crew Aboard the International Space Station

Mary L. Lozano
Clifford Wong

Under the leadership of the United States, thirteen nations are working to build the International Space Station (see Fig. 1), the world's first science and technology laboratory in space and the largest international scientific cooperative project in history. By the year 2003, the National Aeronautics and Space Administration (NASA) and its partners will have completed approximately 45 missions in an effort to fully assemble the Space Station. Construction is scheduled to begin in November of 1997 and in May of the following year, three crew members will be moving in.

As we enter the 21st century, we can expect international space flight missions to be made up of crew members from different nationalities and cultures. Of importance are the potential effects of cultural and interpersonal communication factors on crew interaction, crew operations, and crew-machine interface for multicultural space flight crews. Space-farers from

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different countries will be living and working together within the confined and isolated quarters of the space station. The International Space Station crew will consist of U.S., Russian, Canadian, European, and Japanese personnel. Mission duration can range from 90 to 180 days for space station visits and approximately two years for a round-trip manned mission to Mars. Effective and efficient multicultural crew interaction and operations will assume a major role in flight safety and mission success.

United States astronaut Norman Thagard, in a *Washington Post* article, described his 115-day experience aboard the Mir as one of "extreme cultural isolation," adding:

> I worry really more about longer flights. You're one American on a Russian spacecraft, no one else really speaks English and there were times when I went days without talking to our folks in the mission control center in Moscow, all of which adds up to a fair amount of isolation. It's something we'll have to look at for longer flights (Harwood, July 8, 1995).

NASA Administrator Daniel S. Goldin agrees with Thagard's emphasis on the social problems surrounding long space missions, and believes that Thagard's observations might "turn out to be one of the major findings of this mission."

The international nature of manned space flight missions will require crew members from different cultures to live and work together effectively for long periods of time in space. Different nations will participate in joint manned space exploration missions because the sheer cost and complexities involved will make it extremely difficult for one nation to undertake such endeavors alone. The potential impact of cultural dynamics on multicultural crew operations and interaction is an extremely important issue. Smooth and efficient multicultural crew interaction (crew-to-crew and crew-to-ground personnel) and crew operations are crucial for flight safety and mission success.

In the past, within one country's astronaut corps, candidates typically were all Caucasian males who were socially, educationally, and physically similar. Despite the homogeneity of the crew, members sometimes did experience tense moments, but these personal differences were minimized for the sake of the mission. Reports of strained relationships from actual manned space flight experience raised concern, especially when these incidents occurred in homogeneous crews that were rigorously selected and highly trained for the mission (Oberg & Oberg 1986; Lebedev 1990). While the Apollo and Gemini crews functioned well together in space, many of these former astronauts stated that interpersonal problems might grow in intensity as missions grow longer and crews increased in number and become more culturally mixed.

If American astronauts experienced conflicts with crew members of their own culture, how much more disruptive would interpersonal problems be with multicultural crews? It is not surprising that conflicts and misunderstandings occurred on space shuttle missions when American and foreign crew members flew together. Differences in such cultural factors as personal hygiene, gender roles, religious practices, and language resulted in tense moments. Similar situations are known to have occurred on long-term Soviet Russian space missions with astronauts from other nations (Oberg & Oberg, 1986).

The International Space Station crew is going to be even more heterogeneous with crew size just as large or larger than current space shuttle missions. Not only will there be crew members of different sex, ethnicity, scientific and educational backgrounds, and professional status, there will also be a growing number of crew members from different cultures. For the joint multicultural space venture to generate successful results, those involved need to be well prepared for interacting with people from cultures other than their own. Confined participants on isolated missions will experience hardships and social deprivation because they are relegated to a micro society unlike anything they have ever dealt with before. As pointed out by Connors, Harrison & Akins (1985), prolonged isolation and confinement intensify the "effects of attitudinal dissimilarities, need incompatibilities, annoying habits, irritating mannerisms, and other sources of interpersonal friction, while reducing the opportunity to express dissatisfaction" (p. 10). Based on a series of reviews from 60 American and former Soviet space simulation studies, Kanas (1987) suggests that much research is needed in the area of interpersonal issues with regard to crew heterogeneity, such as mixed gender and diverse cultural groups.

The McDonnell Douglas Study

In 1992, an independent research and development (IRAD) project was conducted at McDonnell Douglas to provide information on how key cultural and interpersonal communication factors could affect multicultural crew operations and interaction during international manned space flight missions. The objective of the project was to identify and derive key cultural and interpersonal communication factors for multicultural space flight crews.

To achieve the study's objective, a *literature search* was conducted, *interviews* were arranged with active duty and retired astronauts, and a *survey* and a multicultural crew factors *questionnaire* were designed and administered to national and international space agency personnel. Unfortunately, at the time of the study, Russia was not one of the international partners of the space station effort. Russian subjects are therefore not included.

Literature Review. Given the scarcity of data collected from actual manned space flight missions, a literature search was required to identify relevant earthbound multicultural interactions to determine the importance of multicultural factors for manned space flight, and to establish the significance of these factors to actual space flight crews. Multicultural communications literature identified 11 cultural and interpersonal communication factors considered to be relevant for international manned spaceflight operations. These factors appear in Table 1.

Interviews. Seven astronauts were interviewed for the IRAD; two were retired and five were active-duty astronauts. All of them had had flight experience with multicultural crews. The interviews provided an opportunity to add to the information accessed from the literature about those cultural and interpersonal communication factors that astronauts believe will have a significant effect on multicultural space flight crews.

The seven astronauts provided additional insight into areas they believed would have significant effects on multicultural space flight crews. They referred to the following as major issues for international manned space flight:

- Crew personal hygiene standards and grooming habits. Body odor has different effects on different people, and cultural differences in personal hygiene standards can affect interpersonal relationships.
- Verbal and nonverbal communication. Technical language requires extensive training. Crew members need to understand all systems and the language associated with each system. Humor is very important for space flight, especially in confined and isolated places because it helps to release tension. However, in multicultural crews, the culture might dictate what is humorous to one crew member and not to another.
- Gender. Cultural differences in gender roles, norms, and stereotypes may be extremely important. Such differences have actually created tension and conflict between crew members on actual missions.
- Profession. Professional background and level of professional expertise can affect interpersonal relationships.
- Decision-making processes. For critical or emergency situations that require an immediate response, the two veteran NASA astronauts said that one does not want to sit around trying to get a group consensus about what to do. It is imperative that an individual crew member, such as the commander, make a decision.
- Religious beliefs. This can also create tension and conflict between crew members with differing religious beliefs, thus affecting mission performance and psychological health. In fact, religious differences have caused problems among crews on actual manned space flight missions.

Survey. Based on the information gathered, a survey was designed and distributed to manned space flight personnel from NASA, the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency (NASDA). The respondents consisted of astronauts, crew trainers, administrators, and engineers and scientists from aerospace companies associated with the Space Station program. Survey respondents were instructed to rate the importance of each factor for multicultural crew interaction and operations on the 5-point rating scale for on-duty and off-duty mission segments–5 points for "very important" and 1 point for "not very important." Fourteen cultural and interpersonal communication factors were rated by the respondents and appear in Table 2.

A total of 37 survey respondents were included among the NASA, CSA, ESA, and NASDA groups. Although the subject population was quite small, the respondent groups were matched closely in terms of education, occupation, and age with the type of person that applies to the astronaut corp. It should be emphasized that the groups did not represent the cultural population at large.

For on-duty segments, there were significant differences ($p<.05$) between how Japanese and Western respondents perceived the importance of these factors compared to how American, Canadian, and European respondents viewed the importance of these factors. This fits well with Hofstede's (1980, 1983) and Hall's (1976) cultural dimension framework. While cultures differ in some degree to where they fall along the dimensions of individualism-collectivism, high context-low context communication, uncertainty avoidance, power distance, and masculinity-femininity, Western cultures are generally much closer to each other on these dimensions than they

Table 1. Cultural and interpersonal communication factors derived from the multicultural communications literature.

- Verbal communication
- Nonverbal communication
- Tolerance and respect
- Attitudes, norms, beliefs
- Interpersonal interest
- Task-oriented and relationship-oriented behavior
- Assertiveness
- Conflict resolution
- Decision-making processes
- Role structures
- Human-machine interfaces

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are to the Japanese culture. However, the results also revealed that there were factors in which the American, Canadian, and European respondents differed among themselves.

Questionnaire. Shortly after performing an analysis of the survey responses, a multicultural crew factors questionnaire was created. The questionnaire's 74 respondents (different respondents also from NASA, CSA, ESA, and NASDA) answered multiple-choice questions that dealt with (1) language, (2) cultural flexibility and personal space, (3) management styles, and (4) crew-machine interface design. As with the survey, the answers exposed cultural variations and similarities among the international respondents. For example, the Japanese expressed the most difficulty with the English language. The Japanese also differed significantly from Westerners in the difficulty they face in discussing religion, politics, or finance. The Japanese also referred to discomfort in the acceptance of a female leader. Americans placed a higher value on religion than did the other groups. Although cleanliness and dental care were rated as important to everyone, the Japanese found personal appearance and hair less important than either the Americans, Canadians, or Europeans. While most Westerners valued independent thinking, less than half of the Japanese respondents felt similarly.

What the Study Accomplished. The main thrust of the IRAD was to determine how differences in cultural norms and beliefs could impact multicultural crew operations and interaction on international manned space flight missions. Three major aims were achieved by this study. First, the study played a major role in igniting the interest and concern of national and international manned space flight personnel in multicultural crew factors. Second, it identified 14 key cultural and interpersonal communication factors that could impact multicultural crew interaction and operations. Finally, it assessed some of the attitudinal trends and patterns of American, Canadian, European, and Japanese manned space flight personnel regarding these 14 "multicultural" factors.

Table 2. Cultural and interpersonal communication factors rated in the McDonnell Douglas survey.

- Language
- Nonverbal communication styles
- Task- and relationship-oriented behavior
- Patience and tolerance
- Decision making processes
- Assertiveness
- Interpersonal interest
- Respect for other cultures
- Personal hygiene and cleanliness
- Gender roles and stereotypes
- Conflict management and resolution
- Trust in people
- Scheduling and time management
- Sense of humor

Working for the Future

For most present-day short-duration spaceflight missions, these cultural and interpersonal communication factors should not pose a significant threat to the interaction and operations of highly trained and highly selected astronaut crew members. However, for longer duration missions with larger multicultural crews, there is that threat. Disagreements and conflicts occurred on international Space Shuttle and Mir missions that disrupted crew interaction to varying degrees. When a crew begins to live and work together in a confined and isolated spacecraft for a long duration, these factors can become more pronounced, resulting in hostilities within the space station environment. Wouldn't it be more effective and efficient to deal with these issues on the ground when crew members are in training rather than attempting to manage these problems while the crew is in-orbit or in-flight?

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Hofstede, G. (1983). Dimensions of national cultures in fifty countries and three regions. In J. Deregowski, S. Dzuirawiec, & R. Annis (Eds.), *Explications in cross-cultural psychology.* Lisse, The Netherlands: Swets & Zeitlinger.

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Mary Lozano, Ph.D., is a Human Factors/Environmental Engineer with PRIZIM Inc., Gaithersburg, MD, and Clifford Wong, Ph.D., is a Senior Engineer Specialist with McDonnell Douglas Aerospace West, Huntington Beach, CA.

Calendar

July 29-August 9, 1996
Ann Arbor, MI, USA
Human Factors Engineering. A short course offered by the University of Michigan. Contact Engineering Conferences, 200 Chrysler Center-North Campus, The University of Michigan, 2121 Bonisteel Blvd., Ann Arbor, MI 48109-9990. Tel: 313-764-8490, Fax 313-936-0253.

July 31-August 3, 1996
Breckenridge, CO, USA
5th IEA International Symposium on Human Factors in Organizational Design and Management. Contact Ted Brown, ODAM 96 Secretariat, 2 Belle Aire Rd., Colorado Springs, CO 80906-4204. Tel & Fax: 719-635-8881, Email: jbrown@databahn.net

August 25-27, 1996
Dayton, OH, USA
3rd Annual Symposium on Human Interaction with Complex Systems. Contact Dr. Oscar N. Garcia, Dept. of Computer Science and Engineering, Wright State University, Dayton, OH 45435. Tel: 513-873-5134, Fax: 513-873-5133, Email: ogarcia@cs.wright.edu

September 2-6, 1996
Philadelphia, PA, USA
40th Annual Meeting of the Human Factors & Ergonomics Society, “Key to the Future.” Hosted by the Delaware Valley Chapter in cooperation with the South Jersey Chapter. Contact HFES, PO Box 1369, Santa Monica, CA 90406-1369. Tel: 310-394-1811, Fax: 310-394-2410.

September 15-20, 1996
Stockholm, Sweden
25th International Congress on Occupational Health, “For a Good Working Life.” Contact the Stockholm Convention Bureau, ICOH’96, Box 6911, S-102 39 Stockholm, Sweden. Tel: +46-8-736-1500, Fax: +46-8-348-441, Email: stocon@stocon.post.se

September 16-20, 1996
Boston, MA, USA
Industrial Ergonomics: Human Factors in Occupational Health & Safety short course. Contact Nicole Costa, Harvard School of Public Health, Center for Continuing Professional Education, 677 Huntington Avenue, Dept. A, Boston, MA 02115-6023. Tel: 617-432-1171, Fax: 617-432-1969, Email: contedu@sph.harvard.edu

October 7-11, 1996
Boston, MA, USA
Fundamental of Industrial Hygiene short course. Contact Nicole Costa, Harvard School of Public Health, Center for Continuing Professional Education, 677 Huntington Avenue, Dept. A, Boston, MA 02115-6023. Tel: 617-432-1171, Fax: 617-432-1969, Email: contedu@sph.harvard.edu

October 7-11, 1996
Copenhagen, Denmark
AGARD Aerospace Medical Panel Symposium on Audio Effectiveness in Aviation. Contact AGARD/AMP, 7 Rue Ancelle, 92200 Neuilly-sur-Seine, France. Tel: +33-1-47-38-57-60, Fax: +33-1-47-38-57-90.

October 23-25, 1996
Stratford-Upon-Avon, United Kingdom
1st International Conference on Engineering Psychology and Cognitive Ergonomics. Contact Dr. Don Harris, Dept. of Applied Psychology, College of Aeronautics, Cranfield University, Cranfield, Bedford MK43 0AL, UK. Tel: +44-1234-750111 ext 5196, Fax +44-1234-750192, Email: icep@cranfield.ac.uk

November 7-9, 1996
Mescalero, NM, USA
AGARD Aerospace Medical Panel Specialist Meeting on Impact Head Injury: Responses, Mechanisms, Tolerances, Treatment, & Countermeasures. Co-sponsored by the Society of Automotive Engineers (SAE). Contact AGARD/AMP, 7 Rue Ancelle, 92200 Neuilly-sur-Seine, France. Tel: +33-1-47-38-57-60, Fax: +33-1-47-38-57-90.

November 11-13, 1996
Taipei, Taiwan, ROC
4th Annual Pan Pacific Conference on Occupational Ergonomics, “Ergonomics, Safety, Productivity, Quality.” Contact Prof. Mao-Jiun J. Wang, Ergonomics Society of Taiwan, Dept. of Industrial Engineering, National Tsing Hua University, Hsinchu 30043, Taiwan, ROC. Tel: +886-35-715131 ext 3956, Fax: +886-35-722685, Email: est@ie.nthu.edu.tw, WWW: http://www.ie.nthu.edu.tw/~PPCOE/

November 18-20, 1996
Madrid, Spain
AGARD Aerospace Medical Panel NATO Flight Surgeons Refresher Course. Co-sponsored by the Society of Automotive Engineers (SAE). Contact AGARD/AMP, 7 Rue Ancelle, 92200 Neuilly-sur-Seine, France. Tel: +33-1-47-38-57-60, Fax: +33-1-47-38-57-90.

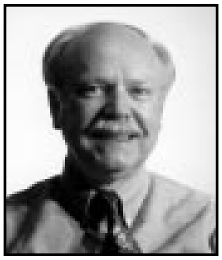
April 15-17, 1997
Grantham, United Kingdom
The Ergonomics Society Annual Conference 1997. Contact Conference Manager, The Ergonomics Society, Devonshire House, Devonshire Square, Loughborough, Leicestershire LE11 3DW, United Kingdom. Tel & Fax: +44-509-234904, WWW: http//www-hcs.derby.ac.uk/ergonomics/ *Offers of papers and workshops are invited. Deadline for abstracts of papers is September 20, 1996.*

June 29-July 4, 1997
Tampere, Finland
13th Triennial Congress of the International Ergonomics Association, “From Experience to Innovation.” Contact Prof. Markku Mattila, Tampere University of Technology, Occupational Safety Engineering, PO Box 589, FIN-33101 Tampere, Finland. Tel: +358-31-3162-621, Fax +358-31-3162-671, Email: mattila@cc.tut.fi

August 24-29, 1997
San Francisco, CA, USA
HCI International ‘97. 7th International Conference on Human-Computer Interaction jointly with 13th Symposium on Human Interface (Japan). Contact Dr. Gavriel Salvendy, General Chair, or Kim Gilbert, Conference Administrator, School of Industrial Engineering, Purdue University, 1287 Grissom Hall, West Lafayette, IN 47907-1287. Tel: 317-494-5426, Fax: 317-494-0874, Email: salvendy@ecn.purdue.edu

Notices for the calendar should be sent at least four months in advance to:
CSERIAC Gateway Calendar, AL/CFH/CSERIAC Bldg 248, 2255 H Street, Wright-Patterson AFB OH 45433-7022

The COTR Speaks



Reuben L. Hann

Cultural differences typically do not impact our daily lives–unless we are submerged in an environment where they are continually present. Such is the case with the International Space Station, the world's first science and technology laboratory in space. It will be developed by 13 nations with each providing crew members. In this multicultural setting, cultural factors will affect crew interaction, crew operations, and crew-machine interfaces. In this issue of *Gateway*, Dr. Mary Lozano and Dr. Clifford Wong describe some of the problems that may arise in multicultural settings and how McDonnell Douglas has studied them in an effort to prevent disruption of space missions.

Also in this issue, Dr. Ron Schopper, CSERIAC Chief Scientist, provides his first installment on the recent past meeting of the U.S. Department of Defense Human Factors Engineering Technical Advisory Group. This particular meeting was hosted by NASA at the Johnson Space Center, Houston, Texas. Ron provides an interesting tour of the NASA facilities via the written word! An overview of the meeting itself will appear in the next issue.

Dr. Gary Olson, University of Michigan, spoke as part of the 1995 Armstrong Laboratory Human Engineering Division Colloquium Series. Here, a synopsis of his presentation on "Technological Support for Distributed Work Groups" is given by Dr. Randy Whitaker of Logicon Technical Services Incorporated followed by an edited selection of a conversation I had with Gary following his presentation.

Continuing our series on human factors laboratories around the world, this issue looks at the Research Development and Human Factors Laboratory of the FAA Technical Center, Atlantic City, New Jersey. Mr. Dennis Filler and Dr. Michael McAnulty have written a fine article about this facility and its capabilities. Of particular interest is the capability to perform real-time air traffic control simulations.

If you would like to write an article about your human factors laboratory or organization, or have developed a product that might benefit the human factors and ergonomics community, please contact our Editor, Jeff Landis. He will be happy to send you an author's kit and answer any questions you might have.

In closing, I would like to point out that the 40th Annual Meeting of the Human Factors and Ergonomics Society is fast approaching. It will be held September 2-6, 1996 at the Philadelphia Marriott Hotel, Philadelphia, Pennsylvania. Registration forms can be obtained from the Society by calling 310-394-1811.

Reuben "Lew" Hann, Ph.D., is the Contracting Officer's Technical Representative (COTR) who serves as the Government Manager for the CSERIAC Program.

Announcements

The Human Factors and Ergonomics Society (HFES) proudly announces the publication of *Human Factors Perspectives on Human-Computer Interaction: Selections from Proceedings of Human Factors and Ergonomics Society Annual Meetings, 1983-1994.*

Editors Gary Perlman, Georgia K. Green, and Michael S. Wogalter supervised the review and selection of more than 3500 papers to arrive at 79 of the best papers presented at HFES meetings in the last fifteen years.

Each three- to five-page paper addresses one or more of the following aspects of human-computer interaction:

- Analysis (12 papers)
- Design (40 papers)
- Prototyping (12 papers)
- Implementation (5 papers)
- Evaluation (34 papers)
- Other (18 papers)

Topics include human aspects such as vision, error, aging, and novice vs. expert users, and machine aspects such as displays, input devices, and software design. The papers followed a number of methodologies: empirical studies, models/theories, development, case studies, and surveys. Also included are author and subject indexes.

Human Factors Perspectives on Human-Computer Interaction makes a valuable addition to any HCI practitioner's or researcher's library. It is also useful as a reader in undergraduate and graduate classes, and especially as an introduction to newcomers to HCI who are searching for issues and methods that can be employed to investigate those issues.

This book is 8" x 11", 400 pages, paperbound. ISBN 0-945289-05-7. $49 for HFES members; $68 for nonmembers; please add $5 for orders shipped outside the U.S. Add California sales tax for deliveries to CA. Prepayment by check (U.S. $ payable to HFES), MasterCard, or VISA. Quantity discounts on five or more copies (call HFES for information). Book review editors: Review copies are available; call 310/394-1811 or fax 310/394-2410.

The CSERIAC Interface

Aaron "Ron" Schopper

Editor's note: The following is the first part of a two-part article detailing the May 6-9, 1996 Biennial Meeting of the Department of Defense Human Factors Engineering Technical Advisory Group. The second part will appear in the next issue. JAL

Twice a year, I'll be describing events and presentations that I've attended during the semi-annual meeting of the DOD's Human Factors Engineering Technical Advisory Group (DODHFETAG) meeting. In brief, this 4-day event convenes twice each year to facilitate the communication of human-factors-related information among the services (and other government agencies with significant human factors interests, e.g., NASA and FAA). Each meeting is hosted by a particular government laboratory or research facility. And it is the custom for the host to provide tours of its research facilities during one afternoon of the meeting.

In May of this year, the meeting was hosted by NASA's Lyndon B. Johnson Space Center in Houston, Texas. Given the popularity of the recent movie *Apollo 13*, it was a particularly fitting site.

NASA Presentations

As reflected in the aforementioned movie, one of the most demanding ground-based positions is that of the flight controllers (those seated in front of the multitude of computer displays in the large mission control rooms during NASA space flights). These individuals are responsible for the real-time monitoring and interpretation of the tremendous amounts of telemetric data downloaded during each mission. Accordingly, one of the major human factors issues being addressed by NASA is that associated with the information-processing demands being placed upon these flight controllers. Among the presentations I attended were two by Dr. Jane Malin of the Intelligent Systems Branch, NASA-Houston. Both addressed NASA's current initiatives in this area.

"Should you elect to take this mission . . ." According to Dr. Malin, in earlier times, the stream of information continuously being downloaded from space stations or shuttles appeared on the flight controllers' screens as countless lines of alphanumeric coded data scrolling down the screen, each line being pertinent to the change in the status of a particular component. Every left-justified line had a date/time stamp, a coded component identifier, and a coded indication of the nature of the change that has occurred since the previous transmission relating to that component. The flight controllers then faced the daunting task of having to monitor and understand this very dynamic, demanding, real-time information environment; i.e., while viewing this continuous data stream, the controllers were expected to mentally parse, extract, and assimilate pertinent information regarding any particular component of interest; recognize and mentally re-position any out-of-sequence data lines (as the result of the large-scale multiplexing and queueing involved); recognize when data might be missing (and appreciate the implications of same); identify abnormalities when they occurred; and finally (and most importantly) integrate and interpret the meaning and potential consequences of the result. (Sounds like another movie, *Mission: Impossible!*) While these highly trained and dedicated professionals are able to process enormous amounts of information successfully, it is a very challenging experience. Dr. Malin's initial presentation described the work being done to ease the controllers' information-processing workload via the development of event-oriented situation displays wherein the same data are categorized, reformatted, and presented in the order of their actual occurrence–not according to the order of their arrival at the control station.

Cooperative Automation. In further efforts to assist operators cope with mission-related tasks, Dr. Malin indicated that NASA has been developing a sophisticated decision support system. The design philosophy is that of "Cooperative Automation" wherein both the human and the supporting computer have expertise, each contributes to the understanding of the situation, and each may propose responses. This approach reflects a team architecture and is viewed as being much more collaborative and interactive than either of the two more traditional approaches frequently used in related circumstances (i.e., the "Software as Oracle" approach, wherein the human provides the data and executes the response and the computer assesses the situation and identifies the response to be made; and the "Supervisory Control" approach, wherein the software provides the data and executes responses, and the human supervises, expertly assesses the situation, and selects the response). The intelligent systems are derived from action-goal-based task descrip-

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tions. In contrast with some approaches, the human flight controller is considered more reliable than the intelligent system and serves as the backup to same. Human operators are kept in the loop for decisions and critical tasks. Software intelligence is used to support shared team allocations and understanding while minimizing distraction and workload. Within this scheme, task allocations are not fixed. They are dynamic and context dependent, and they are responsive to (as well as constrained by) operational policy, changes in available resources, and the nature of the space operation. As an example of this approach, Dr. Malin provided an extensive description of NASA's "DESSY" (Decision Support System) which supports the ground station mission controller monitoring tasks described earlier.

Advanced Space Vehicles Displays and Controls (ASVDC). Function and task allocation issues were also evident in another NASA presentation. From a larger perspective, Dr. Elizabeth Walden of the Flight Crew Support Division provided a presentation on ASVDCs. She noted that at NASA the human-machine function allocation problem is complicated by the fact that each mission entails the need to address highly interactive human-machine interfaces on both the ground and in space almost simultaneously. Complicating matters somewhat are the resource constraints associated with the recent downsizing. One consequence of the downsizing is an increasing emphasis on the movement of many functions from the ground to the shuttle; another is the shift toward single crew operations. Both of these escalate the importance of the information interface and the crewmembers' ability to interpret and manage information. Issues associated with the style, content, and timing of information presentation become critical, as does the manner in which the operator is enabled to interact with the system. Dr. Walden stated that the approach adopted by NASA entails the decomposition of top-level information requirements into those that are operator-relevant. The need to generate the use of concepts applicable across multiple situations (vs. the provision of specific rules which impose memory loads) is emphasized, as is the provision of "information" (vs. data). To ensure that the most relevant input will be provided, NASA researchers also emphasize the need for speaking directly with astronauts about their previous flight experiences and for directly observing astronauts "in-situ" (e.g., in the actual training simulators). By talking with and observing astronauts, they determine how things have been or are actually performed (contrasted with how they were initially envisioned to have been performed). The use of this user-focused approach is viewed as very important to the design of an appropriate interface and support system.

At another level, Dr. Walden identified other actions as being critical to the incorporation of human factors considerations, e.g., early, frequent, and continuing coordination and communication between the avionics systems engineering and the flight crew engineering design groups. She also indicated that the documents derived from the joint efforts to decompose information requirements at the outset of a mission proved to be helpful in enabling those responsible for human factors issues to justify their positions and to get–and keep–human-factors-related requirements in the final design.

NASA Tours

Neutral Buoyancy Laboratory (NBL). NASA presently has two neutral buoyancy laboratory/training facilities used to simulate weightlessness here on earth. Both are large swimming-pool-like facilities. The newer facility, due to become operational by year's end, will be approximately 200 feet long, 100 feet wide, 40 feet deep and will hold 6.2 million gallons of water. The older facility appeared to have dimensions approximately half those of the new one. Replicas of structures and hardware interfaces that have to be moved, joined, or otherwise manipulated during extravehicular activities (EVAs) are placed in these facilities, and the astronauts, dressed in suits weighted to give each neutral buoyancy, train and practice the tasks they will perform during EVAs. Designers are able to directly observe astronauts encumbered in their space suits, floating neutrally buoyed, in their efforts to use the specially designed tools and equipment provided for them. The NBL provides an invaluable environment for usability testing, one wherein the combination of suit constraints (e.g., reduction of range-of-motion and manual dexterity), proposed procedures, structural hardware design, and specially designed tools are brought together for a very real approximation of the weightless environment to be encountered in space. It is here that the potential need for redesign is frequently exposed.

Graphical Analysis Facility (GRAF). A second facility wherein feasibility, system check-outs, and training are supported is the Graphical Analysis Facility. Here, under the direction of Mr. James Maida, highly sophisticated computer-based anthropometric models of EVA-suit clad astronauts are used to simulate the performance of EVA tasks. These simulations include extensively modeled capabilities of size, reach, and strength as exist in the space environment. Constraints imposed by the EVA suit on these factors are embedded in the models. The simulations are used to assess the astronauts' ability to work with specific tools and perform various assembly tasks and adjustments while in space. Such simulations have proven invaluable in that they document potential design deficiencies before they materialize in expensive hardware. This facility also has extensive capabilities (via the use of in-house-developed software) to depict what the astronauts' eyes will actually see (including shading and highlighting) during their EVA activities. Because the visual environment outside the spacecraft is considerably different from that on earth (there is no filtering or diffusion of the light from the sun), these differences can be substantial, and the ability to anticipate and accommodate them can prove critical to the success of astronauts' efforts. Such modeling capabilities provide, in some instances, the principal means of familiarizing the astronauts with tasks that cannot otherwise be simulated before departure.

Ground Control Rooms. The visit to the present- and the next-generation mission control rooms emphasized the magnitude and complexity of the efforts required to undertake a space mission. While *Apollo 13* provided an impressive depiction of the work of these mission controllers, this portion of the tour provided an enhanced appreciation of their work and the human factors aspects of the operation. The importance of the previously described work on display formatting and navigation, and DESSY, was emphasized by the descriptions of the workstations to be used in the new mission control room (scheduled to become fully operational within the next flight or two). Therein, each controller will monitor a total of 12 active screen areas simultaneously appearing in the quadrants of three large CRTs. Given the large size of the control room and the number of personnel and workstations involved (15-16), there are also the related-but-broader human factors design issues pertaining to the enhancement and maintenance of individual and team situation awareness, team coordination, and team communications (both electronic and verbal).

It was also interesting to learn that each of the dozen or more stations in the control room has a counterpart in the rooms outside-but-adjacent to the mission control room. These can be used in both a back-up mode and as additional real-time problem-solving resources. And these capabilities will be enhaced even more in the new control room where, in contrast to the dedicated roles associated with the workstations in the existing mission control room, each workstation will be rapidly reconfigurable to serve the role of any other.

An outstanding meeting. The host for the meeting provided a rather awe-inspiring experience. I've provided descriptions of only some of the presentations I attended. Others dealt with such topics as the astronaut selection process (approximately 2400 applicants every two years, 120 interviewed, and 15 selected) and the effects of space flight (e.g., strength degradation: if you can bench press 220 lbs. before you leave, you may be down to less than 140 lbs. 10 days or so later when you return).

Overall, by the end of the meeting, NASA provided a clear appreciation that human factors issues can and do play a markedly important role within its operations. All those who made presentions or spoke with us seemed genuinely committed to and proud of their work. Perhaps the fact that space flight remains such an exotic, awe-inspiring accomplishment contributes to this impression. Perhaps it is because we all know that the stakes are extremely high; perhaps it is because there exists such a critical, focused emphasis on the human operator's (astronaut's) role; perhaps it is because each space flight provides a concrete basis for feedback and a sense of specific accomplishment; perhaps . . . I've been around long enough to know that what we saw and heard represented the highlights, that in such a large organization some jobs may be drab, that political factors may take their toll, etc.; however, it sure looked like a great place to practice the profession of Human Factors. (I'd sign up in a heartbeat!) ●

Aaron "Ron" Schopper, Ph.D., is the Chief Scientist for the CSERIAC Program Office.

Product Announcement

CASHE AVAILABLE!

Please note that the CASHE (Computer Aided Systems Human Engineering) CD-ROM is available for shipping. To order your copy for $395 (plus shipping), contact:

CSERIAC Program Office
AL/CFH/CSERIAC Bldg 248
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Wright-Patterson AFB OH 45433-7022
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Want to See Your Name in Print? Provide Recognition for Your Organization or Laboratory?

CSERIAC is seeking high-quality, publishable material relating to the areas of human factors and ergonomics. Several types of publishable material are being sought.

We are developing a series of articles for publication in the *CSERIAC Gateway* what will highlight organizations, laboratories, and institutes (government, non-government, and academic) that perform research in the areas of human factors and ergonomics (see the second article in the series on page 14). If you would like to provide some recognition for your organization, we would be interested in obtaining an article that describes it. *Gateway* has a circulation of approximately 9,000 that reaches both national and international readers. Contact Jeff Landis, CSERIAC Publications Manager & Editor, for an author's kit.

Want to write a book? If you are interested in writing a book (or compiling and editing a book) relating to a timely human factors or ergonomics topic, contact Ron Schopper, CSERIAC Chief Scientist, for further information. We have some funding to support such efforts.

Contact Jeff Landis via email at *landis@cpo.al.wpafb.af.mil* or by telephone at 513-255-4099. Contact Ron Schopper via email at *schopper@cpo.al.wpafb.af.mil* or by telephone at 513-255-5215. Alternatively, contact either by writing to their attention at CSERIAC (see back cover for address).

Dear CSERIAC...

To show the diversity of support that CSERIAC provides, this column contains a sampling of some of the more interesting questions asked of CSERIAC. In response to these questions, CSERIAC conducts literature and reference searches, and, in some cases, consults with subject area experts. These questions have been compiled by David F. Wourms, Technical Inquiry Group Manager. If you would like to comment on any of these questions or issues related to them, please write to "Dear CSERIAC" at the address found on the back cover of *Gateway* or email Dave Wourms at wourms@cpo.al.wpafb.af.mil.

- A human factors engineer representing a DoD contractor contacted CSERIAC to request information on human tolerance to vibration and shock caused by Howitzer fire.

- A researcher from an Army laboratory contacted CSERIAC for information on modeling the 95th percentile male hand. Information on modeling tools and anthropometric data were of particular interest.

- A professor at the USAF Academy requested information on and points of contact for human factors in aviation videos.

- A researcher from a European commercial airline contacted CSERIAC for information on situation awareness and controlled flight into terrain, specifically dealing with ground proximity sensors.

- A department head from the Navy contacted CSERIAC to obtain a comprehensive list of researchers in the field of human-computer interaction.

- A human factors technician representing a baby products manufacturing firm contacted CSERIAC to obtain point-of-contact information for organizations that distribute infant and child mannequins.

- A university graduate student contacted CSERIAC and requested information on task analysis techniques and man-machine interaction design and prototyping.

- A human factors engineer from a prominent Midwestern manufacturing firm contacted CSERIAC and requested information and points of contact on the topic of 3D head and face models to use in the design of face masks.

- A doctoral candidate contacted CSERIAC and requested references and point-of-contact information for the topic of reliability analysis.

- A systems engineer contacted CSERIAC and requested current references pointing to acceptable times for display latency in force stick use.

Armstrong Laboratory Human Engineering Division Colloquium Series

Technological Support for Distributed Work Groups

Gary M. Olson
Synopsis by Randall Whitaker

Editor's note: Following is a synopsis of a presentation by Dr. Gary Olson, University of Michigan, as the second speaker in the 1995 Armstrong Laboratory Human Engineering Division Colloquium Series: Human-Technology Integration. This synopsis was prepared by Dr. Randall Whitaker, Logicon Technical Services Incorporated. JAL

Dr. Gary Olson, Professor of Psychology at the University of Michigan, is Director of that university's internationally known computer supported cooperative work (CSCW) research center–the Collaboratory for Research on Electronic Work (CREW). CREW focuses on the design of new organizations and the technologies of voice, data, and video communication that make them possible.

In this colloquium, Dr. Olson presented and discussed research on human factors issues of close-coupled cognitive work within teams that are either co-located or geographically distributed. For several years, this research has been pursued with a "multi-method" strategy, involving both laboratory and field studies on group work supported by both traditional and innovative information technology (IT) means.

Field Studies of Work Groups

Numerous design group meetings were intensively recorded and analyzed, with much attention to group dynamics and design rationale. The goal was to collect empirical data on design meetings and determine what needs existed that could be addressed with IT. Such analyses are labor-intensive–usually requiring 60 hours' work for every 1 hour of meeting observed. Analysis of field data revealed a typical pattern of interaction in which one-third of meeting time was spent clarifying ideas and positions, and many ideas introduced were subsequently lost.

Lab Studies of IT Support for Co-Located Teams

Laboratory studies of design groups confirmed the interaction patterns noted in the field study analyses. Interesting trade-offs were indicated in other experimental studies comparing traditional meeting support tools and the collaborative editor tool ShrEdit. Although subjects preferred working with traditional tools, the data indicated they achieved better team focus and produced work of better ranked quality when using ShrEdit.

Lab Studies of IT Support for Distributed Teams

A series of studies compared face-to-face meetings (with and without IT support) with remote work using audio and audio/video links. The interaction patterns noted in the field studies were evident in all conditions. The main performance costs for remote work concerned meeting management and issue clarification. Again, subjects significantly preferred traditional face-to-face interaction without IT support. However, there was no significant performance difference between remote modality and face-to-face meetings with IT support (all of which produced results of higher ranked quality than the traditional case). Adding video produced no significant performance gain over remote work using audio alone, but subjects preferred it.

Field Studies of IT Support for Distributed Teams

The most recent project has been studying and supporting scientists' interaction within the Upper Atmospheric Research Collaboratory (UARC), a project funded by the National Science Foundation. With the addition of network links in 1990/1991, scientists in the USA and Denmark can use research instruments at the Sondrestrom Upper Atmospheric facility in Greenland without the arduous and expensive winter trips there. CREW faculty and scientists have carefully observed the work of the UARC teams of scientists who study phenomena such as "northern lights." Their observations have become part of building a networked system of computerized display and group discussion tools linking the researchers' home laboratories to each other and the Greenland instruments. A large longitudinal study of the user community has been conducted and a suite of team support software has been developed. The initial IT tools have relaxed prior constraints on UARC collaboration and the users are adapting their practices accordingly.

Armstrong Laboratory Human Engineering Division Colloquium Series

A Conversation with Gary Olson

Reuben L. Hann

Editor's note: Following is an edited transcript of a conversation with Dr. Gary Olson, University of Michigan. (see Fig. 1) He spoke on "Technology Support for Distributed Workgroups" as the second speaker of the 1995 Armstrong Laboratory Human Engineering Division Colloquium Series: Human-Technology Integration. The interviewer was Dr. Lew Hann, CSERIAC COTR. JAL

CSERIAC: How did you get interested in collaborative research? Could you say a bit about your training and the events that shaped your research direction?

Dr. Olson: I went from studying psychology in graduate school straight into the Navy. I ended up working at a human factors lab in New London, Connecticut. Having come directly from graduate school—where the problems were all being defined by theoretical controversies and such—then being thrust into this very applied setting, it was a jarring experience on the one hand, but it was also an eye-opener to learn how interesting these real-world problems were. So, by the time I got back into academia, the experience had colored my interests a lot. I picked up some of the things I had been working on previously in graduate school, but I soon found the applied problems to be much more interesting.

About this time I met Judy, who was later to become my wife. She was committed to working in human-computer interaction, an area she had become involved in while with her former employer, Bell Labs. So, the first fall she was back at Michigan, she and I and two others ran a seminar where we read the Card, Moran, and Newell book, *The Psychology of Human-Computer Interaction*. For me, that sort of "clicked together" several streams of interest and I began to do work in the human-computer interface area. Then a colleague of mine, Dan Atkins, an Associate Dean in the Engineering College, spearheaded a project at the National Science Foundation, called the EXPRES Project, whose mission was to build technology which would allow scientists to submit their proposals and have them reviewed electronically. A lot of this had to do with handling multimedia documents and technical issues of interoperability, but we often thought of it as an opportunity to begin to look at how you could support collaboration, because you had scientists who wanted to co-author documents. So we focused on those aspects of it. That got me out of single-user human-computer interactions into multi-user settings. Things just sort of mushroomed since then.

CSERIAC: The World-Wide Web has become the way to seek information and to communicate with others on the Internet. But originally, this was developed as a collaborative tool for scientists, wasn't it?

Dr. Olson: There's a difference between the Web itself and the browser software used to access it, such as Netscape or Mosaic. The Web came out of a research group at CERN in Switzerland, whose aim was to create a kind of international information network. But it was the group at NCSA (National Center for Supercomputer Applications) in Illinois, whose original vision was to create an Internet-based collaborative environment. The original software they were developing was called Collage. It had to do with accessing, sharing, and collaborating over complex scientific visualization activities—the kinds of things you use supercomputers to produce. They had a lot of single-user visualization tools, and they wanted to bring together all these tools, collaborative capabilities of various kinds, as well as access to information bases. For whatever reason, they chose to work on the information access problem first; that's where Mosaic originated. It overwhelmed them and they have only recently gotten back to developing Collage.

CSERIAC: I understand from the conversations today that you will be working with the folks at NCSA again. What kind of activity are you planning?

Dr. Olson: The discussions with them started last summer, then some of them visited Michigan in the fall, and finally, we went to Illinois. The idea is, since we have been working on the collaborative part of the problem, and they have been working on the information access part, that essentially, we have been jointly studying the complementary aspects of what a "collaboratory" should be. So we are at a point where we are using these relatively advanced prototypes we have built using the NextStep world, and we are now going to rebuild the system, partly to solve some architectural problems and partly to make it be platform-independent. It is a natural time for us to have these discussions with NCSA, because they are talking about making some of their browsers interoperate easily with systems we build, and vice-versa. There has been a lot of discus-

Figure 1. Gary Olson, University of Michigan.

sion about interchange formats and related topics, which would allow everything to work together nicely. These discussions are continuing right now.

CSERIAC: I often ask my guests what kind of project they would undertake, if they had no resource constraints—either in terms of personnel or funding. What sort of research program would you initiate under these circumstances?

Dr. Olson: I think I would take some of these problems back into real-world settings, on a bigger scale than we have so far. The main line of our work has been these laboratory tasks. They were anchored in some initial field work, but as we began to develop technologies, we made a specific effort to keep them "simple" and "shaped to the situation." As time has passed, we have understood better the space of technological possibilities, and have analyzed things that other people have built; we have, for example, done some taxonomic work on groupware and similar technolgies.

I feel really ready to build some serious tools for serious work, and then to study their use in actual work settings. I think we have had a fair amount of industrial support and have lot of contacts; I think we could find the settings. I would really like to do some pretty ambitious field work, building systems, deploying them, and evaluating them in field settings.

I think the critical thing—and this is where it gets expensive—is to instrument these projects sufficiently, so that you can understand what actually occurred. The collection of behavioral measurement data often gets skipped. So, you often end up with a few case studies and don't really know what happened. ●

The FAA Technical Center: Research Development And Human Factors Laboratory

Dennis L. Filler
D. Michael McAnulty

In the Aviation Safety Research Act of 1988 (Public Law 199-591), the United States Congress mandated that the Federal Aviation Administration (FAA) make a special effort to focus on human factors in civil aviation. In response to this mandate, the FAA established the Research Development and Human Factors Laboratory (RDHFL) within the Human Factors Branch of the FAA Technical Center located near Atlantic City, New Jersey. The RDHFL, which became operational on November 2, 1992, provides a state-of-the-art facility where aviation-related human factors issues are studied in a controlled scientific environment.

The mission of the RDHFL is to perform research to acquire a better understanding of the part the human plays in current and future aviation systems. This research environment is specifically designed to measure and assess human performance and workload. Additionally, the RDHFL investigates how new technologies should be integrated into air traffic control and airway facilities systems.

Facility Description

The RDHFL is a multipurpose facility staffed by 35 people with backgrounds in engineering, mathematics, computer science, and psychology. It consists of approximately 10,000 square feet of laboratory space and 6,000 square feet of office space (see Fig. 1). The laboratory includes four Experiment Rooms, which can be used separately or together. Each experiment room has its own Experiment Operator Station (EOS). Video and audio links allow communication among the four Experiment Rooms and between the Experiment Rooms and the RDHFL Briefing Room. While an experiment is in progress, observers can unobtrusively monitor the experiment in either the EOS or the Briefing Room.

The RDHFL is designed to be flexible and expandable. Most physical structures (e.g., movable walls), voice and electronic communications, computers, and system peripherals are modifiable and reconfigurable. Voice communications and data networks link the RDHFL with other simulation laboratories at the FAA Technical Center and other research facilities. Outside communications links can be easily integrated with the lab networks to meet the needs of an experiment.

The RDHFL also contains specialty areas. A Blackroom with an audiometric booth provides the capability for conducting perceptual and display evaluation studies that require precisely controlled lighting and acoustic environments. A Virtual Reality room is used to study how applications of virtual environments and advanced visualization might be used to develop future systems. This capability has been used to explore ergonomic design issues related to the Display System Replacement program and the next generation Maintenance Monitoring and Control Facility. Finally, a General Purpose Engineering area provides specialized engineering and integration support for experiments and simulations. Experienced in-house engineers and scientists routinely develop customized hardware and software, and integrate new systems and capabilities into the RDHFL. A recent development in the RDHFL is the capability to perform real-time oculometry studies.

Key Capabilities

The three primary human factors research capabilities at the RDHFL are computer-human-interface (CHI) rapid prototyping, the ability to perform real-time ATC simulations, and sophisticated human performance data collection and analysis capabilities. CHI rapid prototyping is a cost-effective, iterative approach in which a user interface can be developed quickly, evaluated, modified, and reevaluated. The RDHFL has commercially available and custom prototyping tools that can simulate the look and feel of an interface prior to actual software development. RDHFL scientists are currently developing the capability to integrate air traffic control CHI prototypes into end-to-end and part-task air traffic control simulations.

The RDHFL can perform real-time air traffic control simulations of any en-route or terminal air space in the country. Laboratory researchers have also developed generic airspaces for conducting more generalizable experiments. The air traffic control simulator can present realistic air traffic scenarios while collecting the objective and subjective data required to assess an air traffic controller's performance and workload. Once the prototyping capability is integrated with this simulation capability, the RDHFL will be able to evaluate the performance of new systems prior to their physical development.

To measure complex air traffic control and airway facility performance and workload, the RDHFL has developed sophisticated data collection and analysis capabilities. Each Experiment Room has video and audio recording equipment that can be controlled from the EOS. In addition, the computers that simulate air traffic control or airway facility operations or control the equipment under test employ custom data collection software. A central time source is used to synchronize the audio, video, and computer data collection. Once the data are collected, a multimedia data analysis system can replay all audio, video, and computer data simultaneously so that the viewer can correlate objective performance data (e.g., reac-tion times, errors) with any audio or video variable of interest (e.g., the introduction of an audible alarm; a verbal command from a supervisor). Additional postprocessing software is used to reduce the data into aggregate variables.

The RDHFL has performed numerous experiments on human factors issues affecting the performance of pilot, air traffic controller, and airway facilities maintenance work forces. This research is helping to decrease human error through user-centered evaluation activities and by an integrated consideration of the role humans play in the increasingly automated National Airspace System.●

For further information about the capabilities of the laboratory, contact Dennis Filler at 609 485-6454. For information regarding experimentation within the laboratory, contact Dr. Mike McAnulty at 609-485-4752. In addition, either writer can be contacted at:

FAA Technical Center
Bldg 28/ACT-510
Atlantic City Airport NJ 08405

New information regarding the capabilities of the RDHFL can be found on the internet at http://www.tc.faa.gov.

Dennis L. Filler is an Electrical Engineer and Manager of the Research Development and Human Factors Laboratory, and D. Michael McAnulty, Ph.D., is an Engineering Research Psychologist and Manager of the Human Factors Branch, FAA Technical Center, Atlantic City, NJ.

Mailing Address

Please send mailing address changes to:

CSERIAC Program Office
AL/CFH/CSERIAC Bldg 248
ATTN: Jeffrey A. Landis,
Gateway Editor
2255 H Street
Wright-Patterson AFB OH
45433-7022 USA

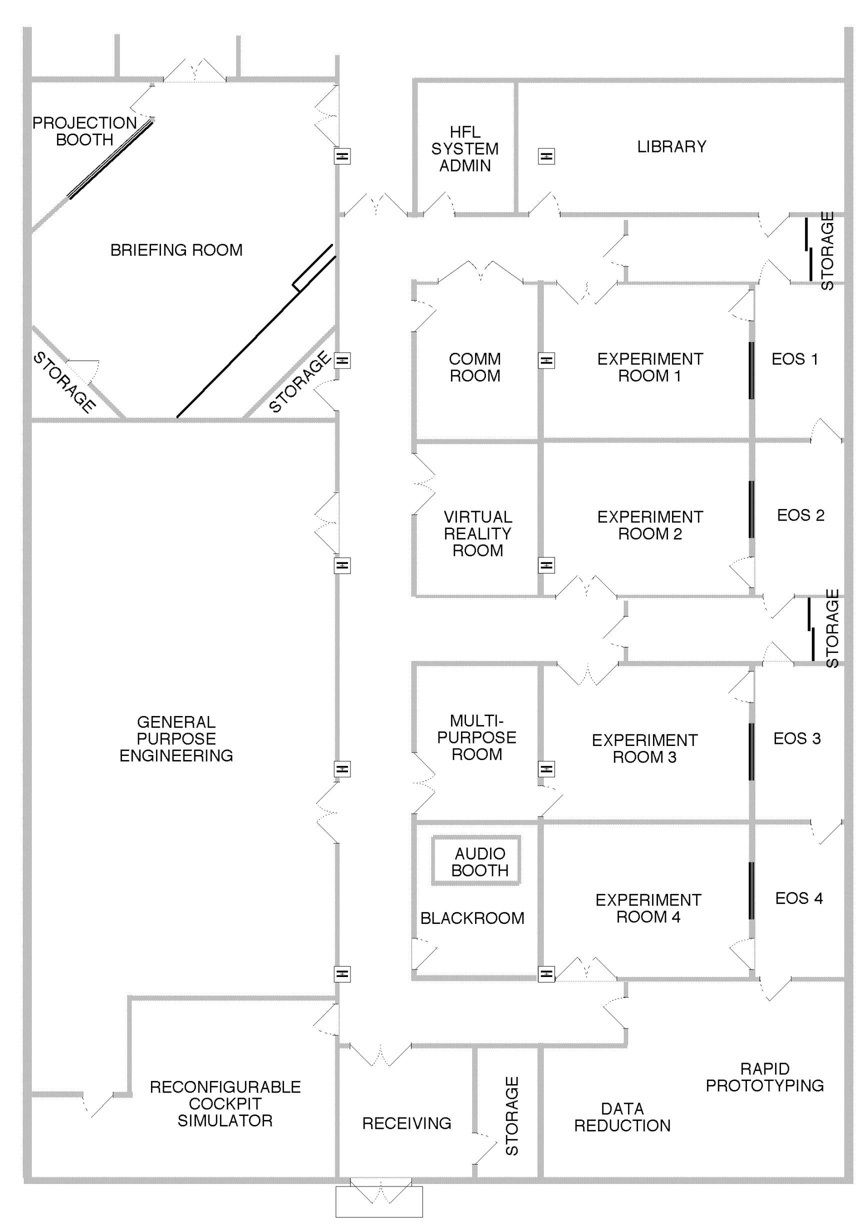

Figure 1. Human Factors Laboratory floor plan.

ARMY NAVY AIR FORCE NASA FAA NATO

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CSERIAC PRODUCTS AND SERVICES

CSERIAC's objective is to acquire, analyze, and disseminate timely information on crew system ergonomics (CSE). The domain of CSE includes scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs, performance, body dimensions, biomechanical dynamics, strength, and tolerances. It also encompasses engineering and design data concerning equipment intended to be used, operated, or controlled by crew members.

CSERIAC's principal products and services include:

- technical advice and assistance;
- customized responses to bibliographic inquiries;
- written reviews and analyses in the form of state-of-the-art reports and technology assessments;
- reference resources such as handbooks and data books.

Within its established scope, CSERIAC also:

- organizes and conducts workshops, conferences, symposia, and short courses;
- manages the transfer of technological products between developers and users;
- performs special studies or tasks.

Services are provided on a cost-recovery basis. An initial inquiry to determine available data can be accommodated at no charge. Special tasks require approval by the Government Technical Manager.

To obtain further information or request services, contact:

CSERIAC Program Office
AL/CFH/CSERIAC Bldg 248
2255 H Street
Wright-Patterson AFB OH 45433-7022

Telephone .... (513) 255-4842
DSN 785-4842
Facsimile .... (513) 255-4823
Government
Technical Manager .... (513) 255-8821

Director: Mr. Don A. Dreesbach; *Government Technical Manager:* Dr. Reuben L. Hann; *Associate Government Technical Manager:* Ms. Tanya Ellifritt; *Government Technical Director:* Dr. Kenneth R. Boff.

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